Effect of food on wine preference by consumers – Evaluation of typical Portuguese ingredients

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Resumo

O presente trabalho pretendeu avaliar a influência da comida e características demográficas e fisiológicas do provador na preferência pelo vinho de acordo com a sua acidez e doçura. O painel de provadores, com treino prévio, foi constituído por 21 indivíduos agrupados de acordo o sexo, a produção de saliva, a sensibilidade ao PROP (6-n-propylthiouracil) e o vinotype. Usando um método de comparação pareada ascendente, verificou-se que a a preferência pelo vinho tinto com e sem açúcar não foi afectada pela comida, tendo-se obtido um limiar de rejeição de 18,4 g/L de açúcar. No caso do vinho branco, os provadores não mostraram preferência significativa pelo vinho adicionado de ácido tartárico (entre 0,8 a 3,2 g/L) em relação ao controlo na presença ou ausência de comida. No entanto, observou-se uma tendência para o aumento de preferência no vinho com 1,6 g/L de ácido tartárico adicionado após a ingestão de comida.

O efeito da segmentação em relação à intensidade e apreciação de ácido tartárico adicionado ao vinho branco permitiu observar correlações significativas ($p<0.05$) entre a produção de saliva e o vinotype apenas na apreciação. Os indivíduos com baixa produção de saliva (<3,5 g/min) preferiram os vinhos mais ácidos. No vinotype, a apreciação da acidez aumentou de acordo com a sequência ”hypersensitive”>”sensitive”>“tolerant”.

Por último, foram avaliados 3 vinhos tintos comerciais em conjunto com comida, pelo painel treinado e por um outro não treinado, através de seriação qualitativa (“ranking”). A análise estatística dos resultados (teste de Friedman) não revelou diferenças entre a seriação dos vinhos antes e depois da comida. A utilização do teste de Pearson’s X^2 não evidenciou mudança na apreciação de cada vinho antes e depois da comida. Em relação a cada provador, o coeficiente de correlação de Spearman mostrou que, no caso do painel treinado em 21 indivíduos 5 mudaram de preferência após a comida. No caso do painel não treinado, a mudança foi observada em 10 dos 22 provadores. Estes resultados sugerem que a variabilidade de respostas dentro de cada painel, ao traduzir-se na ausência de efeito da comida, não permite evidenciar preferências individuais.

Palavras-chave: emparelhamento vinho e comida, segmentação, treinados vs não treinados.

Abstract

The present work intended to assess the influence food and physiological and demographic characteristics of the taster in wine preference according to sweetness and acidity as well as to segmentation based in. The panel test, with previous training, was established by 21 individuals grouped according to gender, saliva production, PROP (6-n-propylthiouracil) sensibility and vinotype. Using a 2 ascending forced choice method, we verified that the preference for red wine with and without sugar was not affected by food, where we obtained a rejection threshold of 18.4 g/L of sugar. In white wines, tasters did not show significant preference for the wine with added tartaric acid (between 0.8 and 3.2 g/L) regarding the control wine in presence or absence of food. However, a tendency was observed for the increasing preference of the wine spiked with 1.6 g/L of tartaric acid after ingesting the food.

The segmentation effect regarding the intensity and appreciation of added tartaric acid to white wine allowed to observe significant correlations ($p<0.05$) between the saliva production and vinotype only in appreciation. The individuals with low saliva production (<3.5 g/min) preferred the most acidic wines. In vinotype, the acid appreciation increased according to the sequence "hypersensitive” > ”sensitive” > “tolerant”.

Lastly, 3 red commercial red wines were evaluated with food, by a trained panel test and by an untrained panel test trough ranking order classification. The statistical analysis of the results (Friedman test) did not reveal differences in ranking before and after food. The Pearson’s X^2 test did not evidence changes in the appreciation of each wine before and after food. Regarding each taster, the Spearman correlation coefficient showed, in the trained panel with 21 tasters, 5 changed the wine position in the ranking. In the non-trained panel this change was observed in 10 out of 22 tasters. These results suggest that the variability of responses in each panel by not showing the effect of food on wine ranking, did not reveal individual preferences.

Key-words: wine and food pairing, segmentation, trained vs non-trained

Resumo Alargado

O presente trabalho pretendeu avaliar a influência da comida na preferência pelo vinho de acordo com acidez, açúcar e em vinhos comerciais. Foi também feita uma segmentação relativa a características fisiológicas do provador através de: (i) testes à produção de saliva (Smith et al., 1996), classificando os provadores como “high producers” (saliva produzida > 3,5 g/min) ou “low producers” (saliva produzida < 3,5 g/min); ao fenótipo individual do gosto ao 6-n-propylthiouracil (PROP) (Pickering et al., 2004), onde os provadores foram classificados como “Supertasters”, “Tasters” e “Non-tasters”; (iii) Vinotype (Hanni, 2012), que é um teste online que avalia as sensibilidades e preferências de provadores, onde os resultados são “Sweet”, “Hypersensitive”, “Sensitive” e “Tolerant”, e (iv) do género.

O estudo foi iniciado com um total de 41 participantes, foram submetidos a várias provas de selecção com soluções aquosas para a identificação das sensações e soluções de vinho com reagentes adicionados, como ácidos ou açúcares. Estas provas serviram para treino. No final desta fase de prática foram escolhidos 21 participantes para o painel final que contou com 7 pessoas do sexo feminino e 14 do sexo masculino, com idades compreendidas entre 21 e 46 anos. Este painel final foi submetido a várias provas como: preferência pelo açúcar usando 5 concentrações diferentes de 2 g/L, 4 g/L, 8 g/L, 16 g/L e 32 g/L de frutose e glucose em quantidades iguais onde se onde se obteve um limiar de preferência pelo controlo em 26,4 g/L de açucar no caso dos vinhos tintos e 32 g/L no caso dos vinhos brancos.

A avaliação da apreciação e intensidade da acidez recorreu a 4 concentrações diferentes de ácido tartárico de 0,4 g/L, 0,8 g/L, 1,6 g/L e 3,2 g/L. Posteriormente, foi feita uma relação entre os resultados desta prova com a segmentação descrita acima. Na prova de preferência pelo açúcar com comida onde foram usadas as concentrações de 2 g/L, 8 g/L e 32 g/L, o prato utilizado foi Bôla de Carne. O limiar de preferência pelo controlo foi de 18,4 g/L de açucar. Na preferência pela acidez com comida, usando as concentrações 0,2 g/L, 0,8 g/L e 3,2 g/L de ácido tartárico e usando o guisado de farinheira, não houve significância nas diferenças mas apenas uma tendência para uma preferência na concentração 1,6 g/l após a comida.

Por último, realizou-se uma prova com 3 vinhos comerciais de três estilos diferentes: Cortes de Cima Aragonez 2013, Dona Graça Reserva 2011 e Luís Pato Vinha Pan 1999, onde foram servidos os vinhos primeiro sem comida e posteriormente com comida. O prato utilizado foi o guisado de farinheira. Esta prova foi feita também a um painel de 22 alunos não treinados para procurar possíveis diferenças. Para o

tratamentos destes resultados foram feitas analises estatísticas, como o teste de Friedman para verificar se existiam diferenças entre os vinhos através da soma dos rankings. De facto, não se obtiveram diferenças entre os rankings antes e depois da comida, nos dois painéis. Foi também feito um teste de Pearson X^2 para testar se as mudanças de ranking observadas eram aleatórias, tendo-se verificado que nos dois casos as mudanças foram aleatórias. Por último, o coeficiente de correlação de Spearman permitiu observar que no painel treinado, constituído por 21 provadores apenas 5 mudaram a posição dos vinhos, após a comida. No caso do painel não treinado em 22 provadores, 10 mudaram a sua resposta. Estes resultados sugerem que a variabilidade de respostas dentro de cada painel é evidenciável mas, quando se tratam os resultados no seu conjunto, as mudanças de posição são divergentes e fazem com que não haja diferenças significativas na apreciação dos vinhos antes e depois da comida.

As conclusões principais deste estudo estão relacionadas com a diferente apreciação dos vinhos em função da produção de saliva e do vinotype dos provadores. Em paralelo, não foi possível evidenciar o efeito da comida na apreciação dos vinhos comerciais quando as respostas foram tomadas no conjunto dos provadores. No entanto, o facto de alguns provadores terem mostrado diferentes preferências com a comida mostra que é necessário, em trabalhos futuros, tentar descobrir as razões que estão subjacentes a este comportamento.

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1. Introduction

1.1 Wine and Food Pairing

“A meal without wine is like a day without sunshine” (Louis Pasteur).

Wine is the most popular beverage in world and it’s appreciated by millions of people. Anyone can taste wine if you taste food. Tasting is the introduction of wine to our senses: sight, smell and taste (Peynaud, 1997). We taste the wine using our senses, the first one, the eyesight, is the one that tends to influence the rest of the tasting, as we do judge a book by its cover. As we smell the wine we try to verbalize what we feel but is not always easy. In the sense of taste we feel different sensations in the same wine: sweetness, acidity, bitterness and saltiness are the main components. The sense of touch is sometimes forgotten but equally important; we feel the body of the wine in the mouth, the silkiness and velvety texture of certain wines (Broadbent, 1998).

Wine and food tasting can be a strategy to improve either a wine or a food. When we pair wine and food the intention is to make the perfect marriage between both items to increase the quality, always making it better. In this pairing process there are some items that are conventionally paired together like white wine and cheese, red wine with steak and chocolate with Port wine (Harrington and Seo, 2015).

Food and wine are strongly bonded in a kind of a cultural meaning. It is growing in popularity over the past decades everywhere (Harrington and Seo, 2015). Wine and food are often seen has a key element in social interactions (Pettigrew and Charters, 2006). In fact, we use food and wine to communicate. So with this important social bonding and experience caused by this link that wine and food can bring, starts the desire to obtain the perfect marriage. Which food goes with which wine or what wine can fit with this food. Due to the complexity of the sensorial interactions between food and wine it’s hard to determine universal guidelines to achieve good pairings (Paulsen et al., 2014). Sadly, in general, people do not like to drink wine in a daily basis and this leads to a gap in matching wine and food instinctively (Harrington, 2008). With a brief investigation, Harrington (2008) observed that the available books on the subject only present wine and food pairings with specific items and sometimes with specific wine varieties, having no deep information about what is behind the match. Information like reactions between food and wine components flavours and textures is therefore very reduced (Harrington, 2008).

We are used to see in some food's menu the specific wine that is best served with that dish. That type of information about food and wine pairing is not helpful for us to understand food and wine pairing, it will not develop people's ability to instinctively match wine and food, in fact, it limits it (Harrington, 2008). The aim of wine and food pairing is to enhance the dining experience (WSET, 2011). The harmony in the wine and food match is achieved by understanding the basic flavour interactions, the pairing should upraise both food and wine and both should taste more pleasantly (WSET, 2011).

1.2 Matching traditions

Harrington (2008) states that countries and cultures have different guidelines concerning wine and food pairing, American uses the "if it feels good, drink it" and French people have rigid rules to follow. According to the Italian perspective of wine and food pairing we should assess each item in four similar categories. For wine there are: i) visual characteristics, ii) olfactory characteristics, iii) taste qualities (sweetness, bitterness, tannins) and iv) overall impressions. For the food we should assess i) visual appeal and color, ii) aromatic character, iii) taste qualities and sensations and iv) the overall impressions.

There are some guidelines, or rules, in wine and food pairing that we are used to hear such as red wine with meat and white wine with fish. This is also a part of the culture. Whilst different cultures and countries have diverse techniques and rules to pair wine and food, the Italian method is based on understanding of the complementary or contrasting elements in food and wine (Harrington, 2008). But also there is a personal preference that influences the matching, for instance it can be an amazing wine and food pairing but if the guest does not like the food item it will not have a happy ending (Harrington, 2008).

1.3 Key Elements in Wine and Food Pairing

There are two main ways to pair wine and food: contrasting or complementary. For example a contrasting match would be a crisp acidity of a dry Sauvignon Blanc with a grilled fat fish. A complementary example is the echo of a raspberry of a young Pinot Noir paired with raspberry reduction sauce (Harrington, 2008).

These combinations are easy to memorize and overall dos and don'ts but they will not help us to understand the reason behind this matches. The matching process of wine and food is influenced by few factors like individual confidence, state of mind and the goal of the gathering where the dinning will happen (Harrington, 2008). There are too many wines and food and too many possible pairings so it is impossible to know it all, that's why it is important to understand the key in wine and food pairing.

There is not an agreement between professionals on what is the most important in the process of matching wine and food. Some defend that should be texture or the body of the food and wine, others defend the flavours are the most important key to match, and also some professionals defend that it should be the primary sensory components like sweetness, saltiness, acidity and bitterness. The terminology describing food (herbal, spicy, fruity, smoky…) is much extended as well as the terms we use to describe wine (dry, oaky, tannic, floral…) so with all this possible elements it is difficult to determine the one key driver behind matching choices (Harrington, 2008). In the book "Food and wine Pairing – A sensory experience", Harrington (2008) establishes a simple way to clarify this issue and to distinguish the key drivers. He separates the elements into three general categories: main taste components, texture elements and flavour elements, as shown in figures 1.1 and 1.2.

In figure 1.1 the pyramid shows a more detailed hierarchy of the wine sensory elements (main components, texture and flavour). In the main components we have three primary elements which are level of sweetness, level of acidity and presence and level of effervescence. In the texture we have a few elements to consider like tannin level, alcohol content, presence and level of oak and overall body. On top we have the flavour where is included identifiable flavour descriptors or types, persistency, intensity and spiciness.

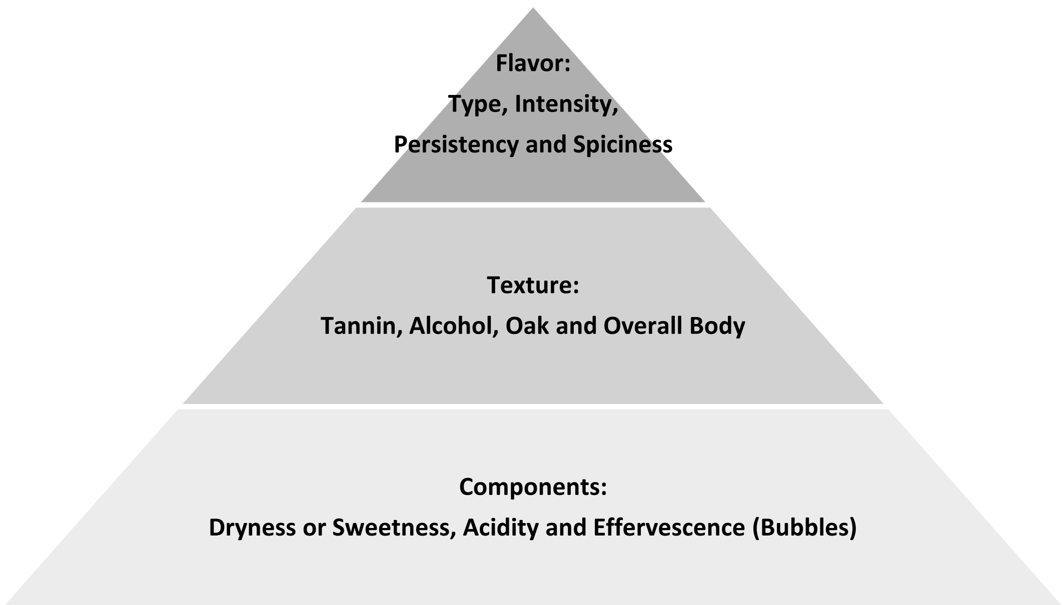

Figure 1.1 Wine Sensations Pyramid (Harrington, 2008).

In the food pyramid (figure 1.2) the foundation category includes level of sweetness (natural or added), saltiness, bitterness and sourness. In the texture category we can consider fattiness level, the cooking technique, and overall body. At the top, concerning the flavour its included identifiable flavour types, persistency and intensity of flavour and spiciness.

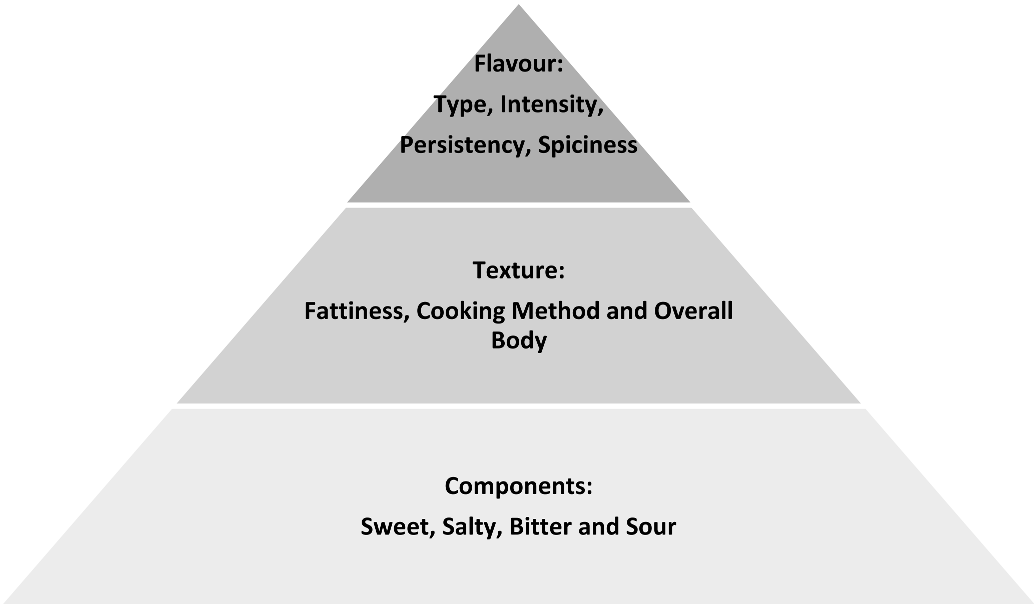

Figure 1.2 Food Sensations Pyramid (Harrington, 2008).

We can bond the pyramids to represent wine and food pairing, similar to the individual pyramid for wine and food. At the bottom the main taste components can be described as the basic elements that corresponds the basic sense perception on the tongue (Rosengarten and Wesson 1989). These components are mostly described as sweetness, saltiness, bitterness and sourness and it is the base for the contrasting or complementary pairing in a pleasant match.

The texture elements are linked to body (Immer, 2002), power (Kolpan et al., 2002), weight (Simon, 1997) and structure (Rosergarten and Wesson, 1989) and it works as glue to the wine and food pairing whether it's by contrasting or complementary match. The texture elements are felt in every place in the mouth rather than a specific part of the tongue like the flavours, and they can be easy to describe. In wine it can be described as thin, velvety, medium bodied or viscous. In food it can be described as grainy, loose, dry, oily or rough. The temperature can also be a descriptor. A way to pair food and wine, by its texture, is using the lightness or richness by complementary or contrasting as long as the richer element does not overpower the lighter pairing item.

The last element is flavour, it is a result of the retronasal process and flavour is the perception of specific characters in food or wine. They are represented on top of the pyramid not for their lack of matter but for the final consideration in pairing (Harrington, 2008).

In table 1.1 are listed the studies related to this subject that are most comparable to our work. Almost every study is made with specific food items and specific wine variety.

Table 1.1 Matching attributes found in studies

Study Details	Consumer group	Attributes		Reference
		Positive match	Negative match	
Wine and cheese	13 member trained panel	Pinot noir w/ Boursin Riesling w/ Grana Padano Pinot noir w/ Gruyere Riesling w/ Danish Blue	Chardonnay w/ Boursin Merlot w/Grana Padano Carbenet Sauvignon w/ gruyere Chardonnay w/ Danish Blue	Harrignton, 2008
Cooked foods and wines	8 trained members	Riesling w/ grilled pork loin Pinot noir w/ grilled pork loin Merlot w/grilled pork loin Cabernet Sauvignon w/ grilled pork loin	Riesling w/ braised beef Pinot noir w/chicken en Papillote Merlot w/ chicken en Papillote Carbenet Sauvignon w/chicken en papillote	Harrington, 2007
Chocolate and beverage pairing	16 participants	Chocolate best match w/ Port wine	Chocolate w/ mineral water	Lambri et al 2012
Sauvignon Blanc, Chardonnay, Cabernet Sauvignon and Port wine, cheeses, salami and chocolate	248 participants ranged in expertise levels and in industry	SB w/ Chevre CD w/ Brie CS w/ Salami PT w/ chocolate	PT w/ Chevre PT w/ Brie PT w/ Salami CS w/ chocolate	Koone et al. 2014
Sauvignon Blanc and Ruby Port with goat cheese and chocolate	79 Students and senior level	SB w/goat cheese and RP w/ chocolate significantly	SB w/ chocolate and RB w/ goat cheese	Harrington & Seo, 2015

1.4 Taster segmentation

According to Harrington (2008) our preference in the process of wine and food can change according to state of mind, self-confidence and the objective of the gathering. For a better understanding and finding out if there is some visible guidelines in wine preference the segmentation process is needed. Segmentation is the process of dividing people into groups using a specific category, for example, age, gender or tasting wine experience. By doing this process of segmentation, we are trying to verify if there is a clear difference in wine preference according to the different consumer segments. Usual distinctions are based on different categories related to demographic, physiological and taste sensitivities, as described below.

Classical segments are based on the gender, age, cultural background or drinking habits (Francis and Williamson, 2015). Taste sensitivity is measured by ingesting a bitter substance (6-n-propylthiouracil or PROP) and evaluating the individual intensity responses. These measures enable the distinction of non-tasters, tasters and super-tasters (Duffy et al., 2004). Tasters rate PROP as moderately bitter, supertasters rate PROP as exceptionally bitter and non-tasters that rate very low (Pickering et al., 2004). Another segmentation is obtained using the saliva production measured by weighing of saliva produced in one minute (Smith et al., 1996), segregating tasters as low or high producers. Other segmentation process may be obtained through the Vinotype which is a self-reported questionnaire evaluating psychological and overall tasting preferences (Hanni, 2012). Individuals are classified as Tolerants, Sensitives, Hypersensitives or Sweets. The sweet type is at the top end scale in terms of sensory sensitivity and is defined as someone always having a preference for sweet wines, tending to prefer more delicate styles, lower alcohol content wines and reds which are especially rich and smooth. Hypersensitive persons are described as tending to love exploring and discovering all sorts of new wines but with very clear preference parameters. Sensitive vinotype is at the center of the sensory sensitivity spectrum, it is the largest segment gathering those enjoying the widest range and diversity of wine styles. A sensitive vinotype person is defined as being flexible, adaptable, and adventurous and a champion of “context” for finding just the “right” wine. The tolerant vinotype defines persons who drink wine regularly, like flavor intensity, full-body and rich mouthfeel (Hanni, 2012).

1.5 Objectives

The study of wine and food pairing is relatively scarce when compared with the sensory evaluation of each one alone. Therefore, our primary objective was to develop an experimental approach to assess wine and food pairing based on literature and on our previous research experience. Our first tests aimed to establishing the preference for wines with modified sweetness and sourness, knowing that these are at the basis of food pairing. Then, we moved on to establish the preference for commercial wines when paired with cooked food. As there are no deep studies regarding evaluation of tastings with wine and food pairings, different types of tasting were tested to assess the most efficient tasting method. Some of the tasters were previously trained to distinguish the 4 basic tastes and segmented according to demographic and physiological features, in order to find possible relation with wine preference.

In summary, our objectives were:

1. To determine the consumer rejection thresholds for sugar in red and white wine.

2. To evaluate the intensity and appreciation to acidity in white wine.

3. To evaluate the effect of food on the consumer research thresholds for sugar content in red wine and for acid content in white wine.

4. To determine the preferred wine to match with a cooked meat dish.

2. Material and Methods

2.1. Participant selection

Two groups of tasters with different training were used. The first panel (panel A) consisted mainly on students of the first year of the Viticulture and Oenology Master (2015/2016). These students were subjected to intense training as described below. The other panel (panel B) consisted of students coming to the first year of the same Master program in following year (2016/2017) without training. In this way we worked with highly motivated individuals with similar education background differing mostly on the wine tasting skills.

2.1.1 Trained participants (Panel A) training sessions

The first training session was made with the basic tastes. The first tasting was with aqueous solutions with the reagents mentioned in table 2.1.

Table 2.1. Reagents and concentrations of aqueous solutions for the first training sessions.

Taste/Sensations	Concentration	Reagent
Sweet	10 g/L	Sucrose
Sour	1 g/L	Tartaric acid
Sour	1g/L	Malic acid
Sour	1g/L	Lactic acid
Bitter	0.0108 g/L	Quinine Sulphate
Astringency	0.8 g/L	Aluminium Sulphate
Astringency	0.5 g/L	Grape Skin Tannin
Hot	10 % (v/v)	Ethanol

The solutions were served in transparent ISO tasting glasses from Schott Zwiesel (Zwiesel, Germany). Participants were given a questionnaire sheet and the tasting had 3 parts. Tasters were asked to detect and recognize the feeling or sensation in the sample. In the first part tasters were given the sucrose, the tartaric, the quinine sulphate, the aluminium sulphate and the ethanol solutions. They tasted and answered in the sheet. In the second part, participants were given two glasses each with a solution of malic acid and lactic acid, respectively, to express the difference between the samples. Lastly, in the third part students were given two glasses with the Aluminium Sulphate solution and Skin Tannin solution, respectively, for the participants to feel the different astringency. We asked the participants to drink water between every sample they tasted and to spit out the sample.

Sucrose was purchased from Sigma (St. Louis, USA), L(+) – Tartaric Acid was purchased from Panreac (Barcelona, Spain). Quinine Sulphate was purchased from Acofarma (Barcelona, Spain), Aluminiumsulphat-18-hydrat was purchased from Riedel-de Haën (Seelze, Germany), Ethanol 96% was purchased from Aga (Lisbon, Portugal), L(-) Malic Acid was purchased from Sigma (St. Louis, USA), DL –Latic Acid was purchased from Sigma (St. Louis, USA), Skin Tannin (Tanin Vr Grape) was purchased from Laffort (Bordeaux, France).

After one week, the second tasting was done with a mixture of the tastes and sensations used in the first tasting, using more than one sensation/taste per glass. In the last 3 glasses we used different wine additives with mouthfeel properties to evaluate their difference, using concentrations and reagents presented in table 2.2.

Table 2.2. Reagents and Concentrations of aqueous solutions for the second tasting

Sensations/ Feeling	Concentration and Reagent
Sour + Sweet	1 g/L Tartaric Acid + 10g/L Sucrose
Sour + Astringency	1 g/L Tartaric Acid + 0,8g/L Aluminium Sulphate
Sour + Sweet + Hot	1 g/L Tartaric Acid + 10g/L Sucrose + 5% Ethanol
Sour + Sweet + Hot + Astringency	1 g/L Tartaric Acid + 10g/L Sucrose + 5% Ethanol + 1 g/L Skin Tannin
Body	2 g/L Soft Gum
Body	0.2 g/L Carboxymethylcellulose
Body	0.6 g/L Mannoprotein

Soft Gum was purchased from A. Freitas Vilar, Lda (Lisboa, Portugal), Carboxymethycellulose (Cistab Gc) was purchased from Proenol (Porto, Portugal), and Mannoproteins were purchased from Laffort (Bordeaux, France).

In the third tasting, after a week, a triangular test was made with white and red wines from ISA. It was a triangular tasting with two control wines and one glass with an added reagent. Participants had to detect and recognize the different sample. The wine based solutions were made with reagents presented in table 2.3. The following tasting (fourth tasting), after a week, was made in the same way because it was noticed a lack of concentration and a difficulty concerning the participants. All the wine's analyses is in appendix III.

Table 2.3. Reagents and Concentrations for the third and fourth tasting

Wine	Sensations/ Feeling	Concentration	Reagent
White	Sweet	30 g/L	Sucrose
White	Sour	2 g/L	Tartaric Acid
Red	Bitter	15 mg/L	Quinine Sulphate
Red	Astringency	1 g/L	Tannic Acid

Tannic Acid was purchase from M&B (Dagenham, England).

The fifth tasting was the last session before the final panel selection. It was a triangular tasting as the third and fourth tastings but with lower concentrations to hamper the tasting. The concentrations and reagents are presented in table 2.4.

Table 2.4. Reagents and Concentrations for the fifth tasting

Wine	Sensations/ Feeling	Concentration	Reagent
White	Sweet	20 g/L	Saccharose
White	Sour	0.66 g/L	Tartaric Acid
Red	Bitter	0.066 g/L	Quinine Sulphate
Red	Astringency	0.5 g/L	Tannic Acid

For selecting the final panel it was considered the results from the last tasting. Participants had to have at least 75% of the correct answers.

2.1.2 Non-trained participants (Panel B)

The students from the first year of 2016/2017 of the Viticulture and Oenology Master were our non-trained panel, to test differences in the results when compared with the trained panel. The students were aged from 20 to 38 years (average 26, standard deviation 5.30).

2.1.3 Selected Panel

The selection begun with 41 students and finished with 21 people, with 7 females and 14 males, age 21-46 years (average 25 years, standard deviation 5.79). There were nine students from the first year of the Viticulture and Oenology Master but also non-enology students. All the participants were asked about their background in terms of studies for since how long they drunk wine, how many times per week do they drunk wine and what they consider themselves about drinking wine (expert, interested or drink for enjoyment). The complete information about participants is in appendix II.

2.2 Saliva flow

The saliva flow (SF) was measured according to the procedure described by Smith et al (1996). Two five minutes session were held over 2 to 3 weeks. During the session the participants were given a sample of 10 ml with a solution of 4 g/L L(+)-citric acid (Merck, Darmstadt, Germany). They were asked to drink the solution and hold it in the mouth, for ten to fifteen seconds, then to spit it out, wait 10 seconds and then spit to a previously weighted plastic cup for one minute. After the tasting the plastic cups were weighted and the total amount of saliva was obtained (Smith et al., 1996). Participants were classified as low producers and high producers according to the weight of the saliva produced.

2.3 PROP Status

PROP status was assessed during two fifteen minutes sessions held over 2 to 3 weeks. Participants rated the bitterness intensity of three PROP (Sigma, St. Louis, USA) solutions (0.032, 0.32 and 3.2 mM) that were present in increasing order of concentration. Individuals were given 20 ml of solution in each glass and instructed to move the solution in the mouth and to gargle for 5 to 10 seconds and to expel the sample (Pickering et al., 2004). After 10 to 15 seconds, they used a gVAS scale (generalized Visual Analog Scale) to rate the bitterness of the samples. According to Pickering et al. (2016) the gVAS scale uses a “no sensation” on the left (0 mm) and on the right “the worst sensation imaginable” (100 mm). After researching the gVAS scale it was noticed that each author uses a different mark on the scale, some use no mark at all (Hayes, 2013) and others at 25, 50 and 75 mm (Pickering et al., 2016). It was decided to use only the 50 mm mark just to have a reference.

Participants were classified as non-tasters, tasters or super-tasters based in the bitterness rating assigned to the 0.32 mM PROP solution using the gVAS scale (non-taster: ≤ 15.5; taster: > 15.5 and < 51; super-taster: ≥ 51; Tepper et al., 2001).

2.4 Vinotype

Vinotype is an online test (www.myvinotype.com) based on the individual’s wine preferences (Hanni, 2012). There are three questions involved that estimate some elements that the individual values in wine. The possible four results are: Sweet, Hypersensitive, Sensitive and Tolerant.

2.5 Intensity and appreciation of tartaric acid

The evaluation of intensity and appreciation of the acid taste was performed using ISA's white wine with added tartaric acid (table 2.5). In this tasting we asked the participants to write on an adapted gVAS scale (Pickering et al., 2016), the intensity of each sample and in another VAS scale the appreciation of each acid concentration. In every sample with added acid the pH was adjusted to 3.58 with sodium hydroxide to make sure there was no influence of this variable on the sensation.

Table 2.5. Reagents and Concentrations for acid tasting

Set of glasses	Reagent and Concentration
1	0.4 g/L Tartaric Acid
2	0.8 g/L Tartaric Acid
3	1.6 g/L Tartaric Acid
4	3.2 g/L Tartaric Acid

2.6 Sugar Preference

After the characterization of the selected panelists the first tasting was the determination of preference for sugar (Sena-Esteves, 2016). This evaluation used an ascending paired forced choice test (2-AFC) based in ISO 5495, first with ISA's white wine then with ISA's red wine, with 5 pairs each, in an ascending forced choice to determine sugar preference thresholds. The panel was asked to taste each sample per pair and to write preferred sample. The concentrations are presented in table 2.6 for either the red or the whine wines. Every sample was identified with a 3 digit code. The wines used were from ISA, all the wine analyses are in appendix III. D(+)-Glucose was purchased from Copan (Lisbon, Portugal) and D-(-)-Frutose was purchased from Sigma (St.Louis, USA).

Table 2.6. Reagents and Concentrations for sugar preference tasting

Pair of glasses	Reagent and Concentration
1	1 g/L Glucose + 1 g/L Fructose
2	2 g/L Glucose + 2 g/L Fructose
3	4 g/L Glucose + 4 g/L Fructose
4	8 g/L Glucose + 8 g/L Fructose
5	16 g/L Glucose + 16 g/L Fructose

2.7 Sugar preference in red wine with food

This tasting was a 2-AFC tasting technique with 3 pairs of glasses, where in each pair there was a control red wine and a red wine with the addition of sugar as described before. The order of the pairs was in an increasing order (2-AFC). Each glass contained 30 ml of wine and was identified with a 3 digit code. The concentrations used in this tasting are in the table 2.7. The wine used was from ISA.

The panel was invited to taste each pair by swallowing or spitting the sample and write in the given sheet the preferred wine in each pair. After tasting the wines, the participants had to take a break from 5 to 10 minutes and drink water to cleanse the palate. After the break, we served a dish with a fatty food “Bôla de Carne”, and participants were asked to taste the food and take a sip of wine and do this process with each sample (to eat and drink for each sample). After tasting each pair of sample, participants wrote the code of the wine that they preferred with the food.

The food used in the tasting was very fatty. It is a type of bread with chorizo, bacon and salami. The bread had oil and during the cooking process the sausages also released their fat. The food was eaten cold as a snack. Recipe is in appendix IV.

Table 2.7. Reagents and concentrations for sugar preference in red wine with food tasting

Pair of glasses	Reagent and Concentration	Total
1	1 g/L Glucose + 1 g/L Fructose	2 g/L
2	4 g/L Glucose + 4 g/L Fructose	8 g/L
3	16 g/L Glucose + 16 g/L Fructose	32 g/L

2.8 Acid preference in white wine with food

Acid preference was evaluated through a paired tasting with 3 pairs of glasses, where in each pair had a sample with ISA’s white control wine and a sample with white wine with addition of tartaric acid. The order of the pairs was in an increasing order considering the concentrations (2-AFC). A two ascending forced choice method was followed to determine preference thresholds. Each glass contained 30 ml of wine and was identify with a 3 digit code according with ISO 5495. The concentrations used in this tasting are in the table 2.8.

The panel was invited to taste each two samples and write in the given sheet the preferred sample in each pair. After the tasting people had to take a break from 5 to 10 minutes and drink water to cleanse the palate. After the break, it was served a plate with a fat food “Guisado de Farinheira”. The base of the dish was Farinheira which is a traditional Portuguese sausage (with flour and pork grease) that is very strong and releases a lot of fat. To this was added bacon, bell pepper, chickpeas, canned tomato pieces, oregano, garlic and chicken stock. Recipe is in appendix V. Participants were asked to taste the food and take a sip of wine and do this process to each sample (to eat and drink for each sample). After tasting each pair of sample, people wrote the code of the wine that they preferred with the food.

Table 2.8. Reagents and Concentrations

Pair of glasses	Reagent and Concentration
1	0.8 g/L Tartaric Acid
2	1.6 g/L Tartaric Acid
3	3.2 g/L Tartaric Acid

2.9 Appreciation of commercial red wines with food

In this experiment we used 3 Portuguese red wines from different regions and with different styles. The first was a smooth Alentejo DOC 2013 awarded with a Great Gold Medal from Mundus Vini Challenge (Spring 2016) Cortes de Cima Aragonez, the second was an astringent and acid Douro DOC 2011 Dona Graça wine and the last was an old wine from Bairrada, a 1999 red-brick colour with high acidity and low astringency Vinha Pan de Luís Pato. The complete analysis to the wines is shown in appendix VI. The dish used in this tasting was the “Guisado de Farinheira”.The wines were served in portions of 25 ml, using the ISO standard transparent glasses and the tasters were asked to drink each wine, drinking water between the wines, and to write their favourite wine. After we served the food and asked the taster to taste each wine with the food. The participants scored the wines indicating the ranking order (ISO 8587) classifieing them as first place (1º), second place (2º) and third place (3º).

2.10 Statistical Analysis

The Analysis of Variance (ANOVA) at α=0.05 was used to compare intensity and appreciation of different levels of tartaric acid globally and according to segmentation. The Tukey HSD (Honest Significant Different) test was used to compare all pairwise differences between means in order to detect significant differences between pairs of wines. All analyses were performed with the software STATISTIX 9.0 (© 2015).

For ranking evaluation, a Pearson's X^2 (1900) was used in commercial red wines tasting results, in order to compare the rank changes that occurred in the test panels with a random change. The numbers corresponding to the ranking given by tasters were: first place (1), second place (2) and third place (3). The hypothesis supporting this test was that the probability of changing the position after food ingestion (ranking order) was random. Thus, in null hypothesis the probabilities are similar to the ones deriving from random choice. In the alternative hypothesis at least one of the probabilities is altered. The observed values (*Oi*) were the direct results from the tasting with the panel and the expected (*Ei*) values were the probability multiplied by the total number (n=21 or n=22) of tasters. The test statistics was:

$$X^2{}_{calc} = \sum_{i=1}^{n} \frac{(Oi-Ei)^2}{Ei} \sim X^2{}_{(k-1)\propto}$$

Having a level of significance of α=0.05 and a critical region unilateral on the right, where we reject H0 if $X^2{}_{calc}$ is greater then $X^2{}_{(3-1)o.o5} \approx 5.991$

Another two approaches were followed, in agreement with ISO 8587, the Friedman test and Spearman correlation coefficient..

The Friedman's test assesses if there are differences between the wines by using the sum of score of each wine:

$$F_{test} = \frac{12}{j \cdot p(p+1)}(R_{w1}^2+R_{w2}^2+R_{w3}^2)-3\,j\,(p+1)$$

where

R_w is the rank sum of wine *w*

j is the number of tasters

p is the number of wines tasted

If F_{test} > 5.99 (critical values for level of significance (α) =0.05, for 3 products assessed by 21 or 22 tasters) (ISO 8587), the null hypothesis is rejected and the wines may be regarded as having different preferences.

The Spearman correlation coefficient studies the agreement between two rank orders.

$$r_s = 1 - \frac{6\sum_i di^2}{p(p^2-1)}$$

where

p is the number of wines tasted

d_i is the difference between the rankings before and after the food for wine *i*

If the value of the Spearman correlation coefficient approaches +1, there is a high agreement between the two rank orders meaning the ranks were kept. If it is close to 0, the rank orders are unrelated. If it approaches -1, there is strong disagreement between the rankings meaning the rank order changed.

3. Results and Discussion

3.1 Respondents characterization

The responses of the participants to the self-reported questionnaires and to the taste functions are summarized in Table 3.1.

Table 3.1. Results from the panel Characterization,

	Segment	Trained Panel	Non-Trained Panel
Gender	Males	14	11
	Females	7	11
Consumption frequency	1 to 3 times/week	15	-
	> 3 times/week	6	-
Consumption history	1-3 years	5	-
	3-5 years	4	-
	> 5 years	12	-
Drinking practice	For enjoyment	1	-
	Expert	7	-
	Interested	13	-
Vinotype	Hypersensitive	4	6
	Sensitive	12	13
	Tolerant	5	3
PROP	Non-tasters	3	8
	Tasters	8	7
	Super-tasters	10	7
Saliva	Low Producers	14	20
	High Producers	7	2

The taste function was evaluated through saliva flow and PROP status. The saliva flow (SF) test was repeated after a couple of weeks to check if the average saliva weight had increased. The average saliva weight for the first tasting was 2.97 g/min and after a pair of weeks it was 3.21 g/min resulting on an average of 3.06 g/min of saliva production. However, these averages were not statistically different ($p>0.05$). Tasters were classified as high producers if saliva produced was greater than 3.5 g/min and low producers if the saliva flow was less than 3.5 g/min. The value 3.5 g/min was chosen after testing significance of different values and concluding that 3.5 g/min had a significant difference between tasters (results not shown). This flow was also the cut-off value determined in previous studies where PROP status was significantly related with saliva flow (Ceciliani, 2017).

The intensity ratings given to PROP status are shown in Figure 3.1 for the trained subjects and in Figure 3.2 for the un-trained subjects. Both tasting panels showed individuals with the 3 different taste phenotypes: non-tasters, tasters and super-tasters (appendix I and II).

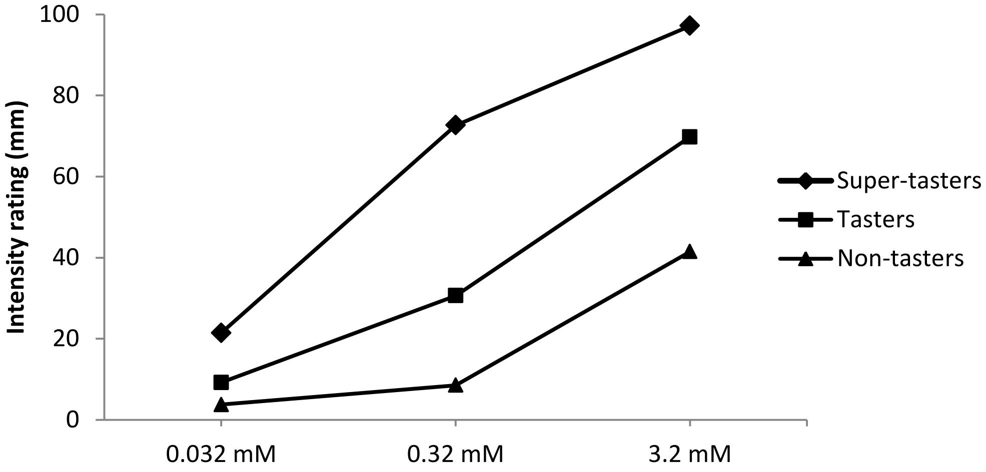

Figure 3.1. Prop status from the trained panel for PROP concentration.

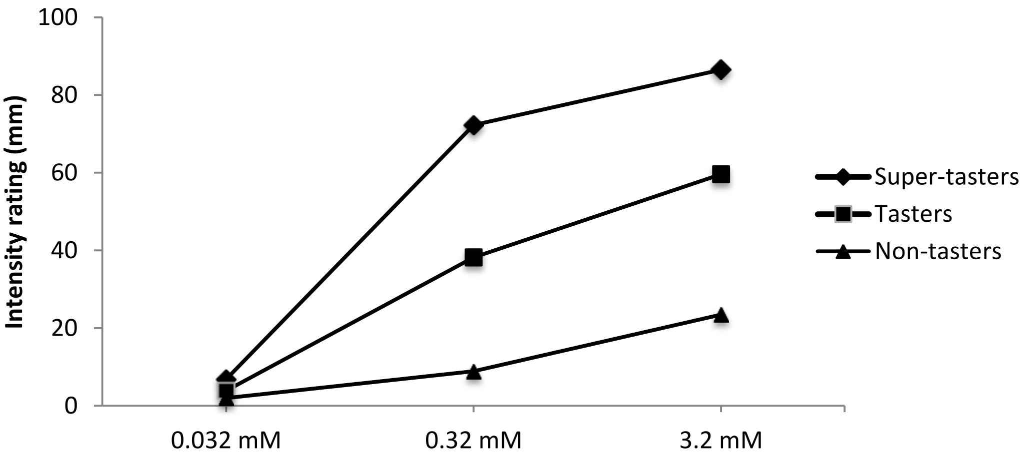

Figure 3.2. Prop status from non-trained panel for PROP concentration.

The two taste functions PROP and saliva flow were not correlated in both tasting panels (Figure 3.3). The correlation coefficient was 0.05 for the untrained panel (p=0.816). The correlation was higher for the trained panel (r=0.362, p=0.128) but still poor. These results agree to the observations reported by Pickering et al. (2004).

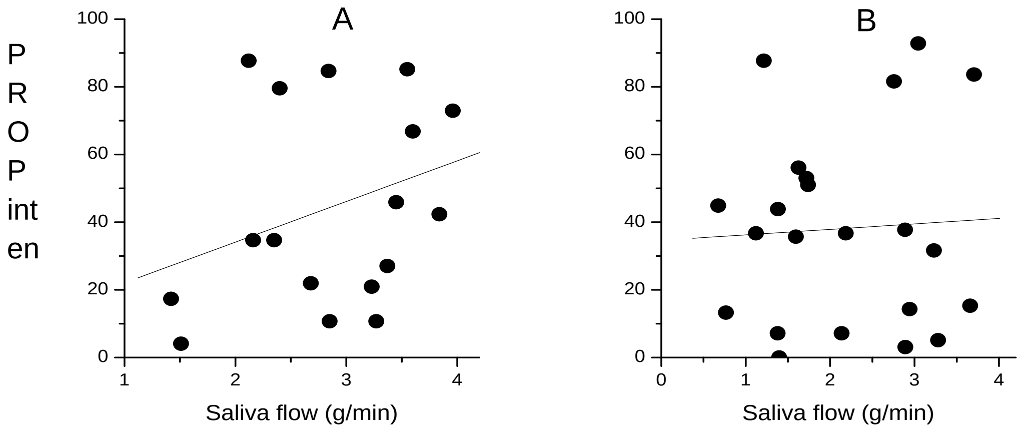

Figure 3.3. Relation between PROP intensity and saliva flow for the trained panel (A) and the untrained panel (B).

3.2 Intensity and appreciation of tartaric acid

The sensory response to increasing concentrations of tartaric was obtained with the trained panel (Figure 3.4). We observed a linear increase in the intensity from 0.4 g/L to 3.2 g/L (Table 3.2). On the contrary, the appreciation responses followed an inverted-U shape curve indicating that 1.6 g/l was the concentration with higher scores (Table 3.2).

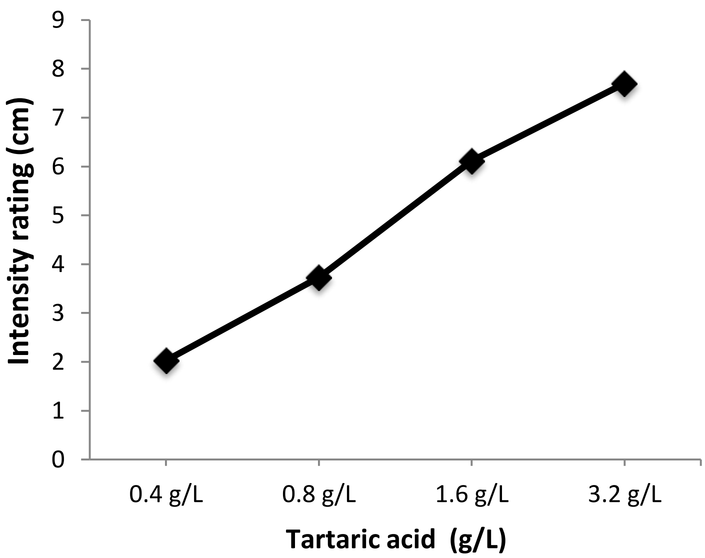

Figure 3.4. Mean intensity ratings as a function of tartaric acid concentration given by the trained tasters.

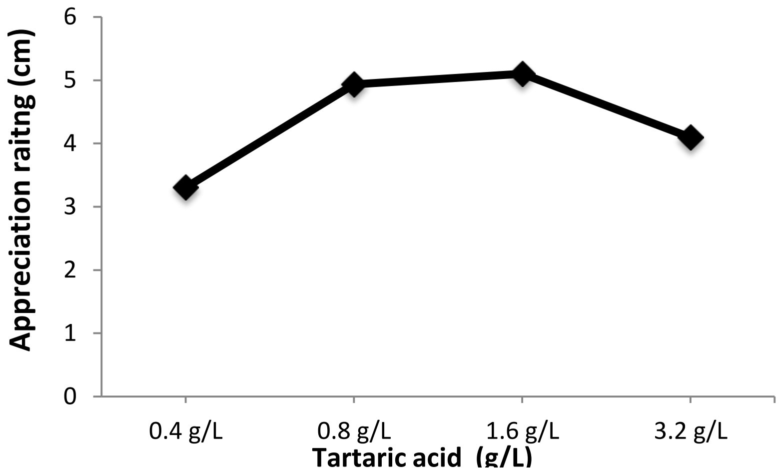

Figure 3.5. Mean appreciation ratings as a function of tartaric acid concentration given by the trained tasters

Table 3.2. Mean scores for intensity and appreciation of tartaric acid given by the trained tasters (SD: Standard deviation).

Tartaric acid (g/L)	Intensity		Appreciation	
	Mean	SD	Mean	SD
0.4	2.03	1.55	3.31	2.27
0.8	3.73	1.87	4.94	2.59
1.6	6.12	1.14	5.10	2.26
3.2	7.70	1.21	4.10	2.74

An ANOVA was performed considering the main taster features and their intensity and appreciation ratings (Table 3.3). We could only detect significant influence ($p<0.05$) on appreciation from saliva flow or vinotype.

Table 3.3. Effect ($p<0.05$) from taster segments in responses to sour taste. (p-value of ANOVA)

	PROP	Saliva	Vinotype	Gender
Intensity	0.0525	0.8965	0.1380	0.3275
Appreciation	0.1212	**0.0367**	**0.0001**	0.2674

The comparison of mean values with the Tukey's test enabled to understand the magnitude of the differences. For the saliva flow, people with low production (<3.5 g/min), appreciated more the acid (mean score 4.78) than the high producers (>3.5 g/min) showing a mean score of 3.57.

With the vinotype, decreasing values of appreciation were found from Hypersensitives (mean 5.41), Sensitives (4.94) to Tolerants (2.44). This means that Tolerants appreciated acidity less (gave lower grades) than Hypersensitives and Sensitives.

The p-value obtained in the ANOVA reflecting the intensity effect of PROP was very near of the value for significance (α=0.05) indicating a strong tendency. In this case Tasters with a mean of 5.19 gave higher grades to intensity than Non-tasters (mean of 3.98) while Supertasters were in the middle range with a mean of 4.96.

When applying ANOVA to each of the tartaric acid concentration to assess the influence of segmentation traits, we observed that the vinotype revealed a significant influence in appreciation of wines with 1.6 g/L of tartaric acid (Table 3.4). In this test, Sensitives had a mean of 6.02 and Hypersensitive had a mean of 5.25 while Tolerants had a mean of 2.66. These results mean that Sensitives and Hypersensitives appreciate acidity more than Tolerants.

Although not significantly, gender tended to influence intensity and appreciation rating of wine with 0.8 g/L of tartaric acid with females giving lower intensity ratings (2.74) than males (4.26) and lower appreciation (3.59) than males (5.66).

Table 3.4. Influence of taster segments in appreciation and intensity for the specific concentrations of tartaric acid (p-value of ANOVA).

	Appreciation				Intensity			
	0.4	0.8	1.6	3.2	0.4	0.8	1.6	3.2
PROP	0.9143	0.1885	0.2080	0.8735	0.7209	0.3726	0.3960	0.1386
Saliva	0.0769	0.6705	**0.0207**	0.9783	0.7290	0.9827	0.8425	0.5509
Vinotype	0.2589	0.1884	**0.0101**	0.1033	0.6767	0.6859	0.2880	0.5769
Gender	0.9423	0.0875	0.6323	0.9259	0.3002	0.0825	0.6065	0.7950

3.3 Influence of food on the preference of modified wine

3.3.1 White wine spiked with tartaric acid

The preference for white wine with different amounts of tartaric acid was evaluated with a 2-AFC method. The results are shown in Figure 3.6 demonstrating that we could not establish a preference for acidity under the tested concentrations of tartaric acid. However a tendency was observed to prefer 1.6 g/L of tartaric acid with the food.

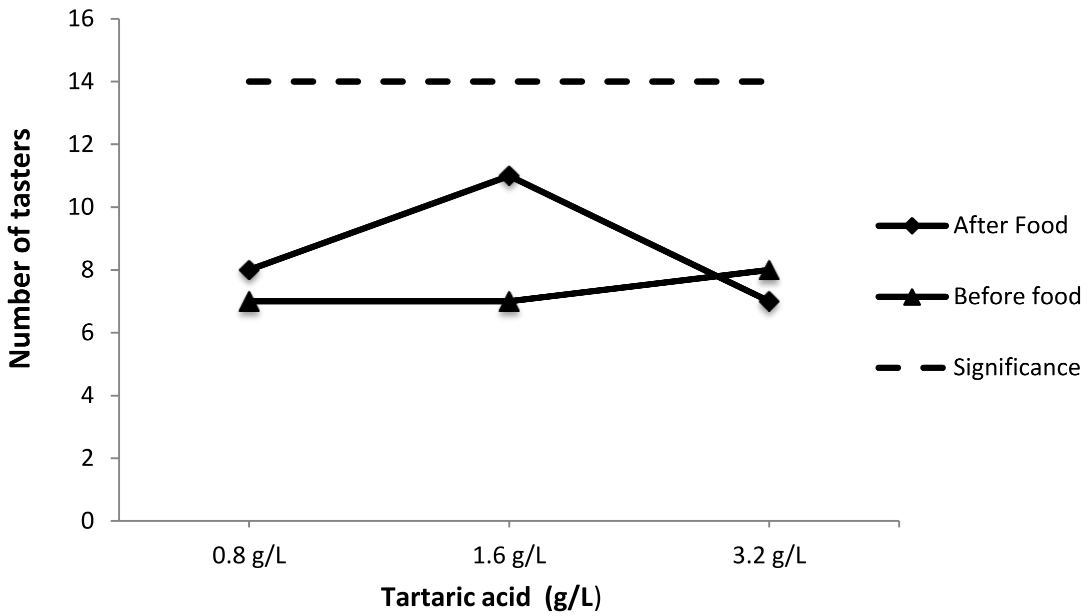

Figure 3.6 Preference wine spiked with increasing concentrations of tartaric acid in relation to control without and with food consumption. Dotted line represents the minimum number of responses (n=14) required to establish significance for a total of 21 respondents.

3.3.2 White and red wine spiked with sugar

The first tests were done in the absence of food to check if the panel behavior was similar to that reported by Sena-Esteves (2016) with red wines. The preference for sugar using wines spiked with increasing concentrations is shown in figure 3.7.

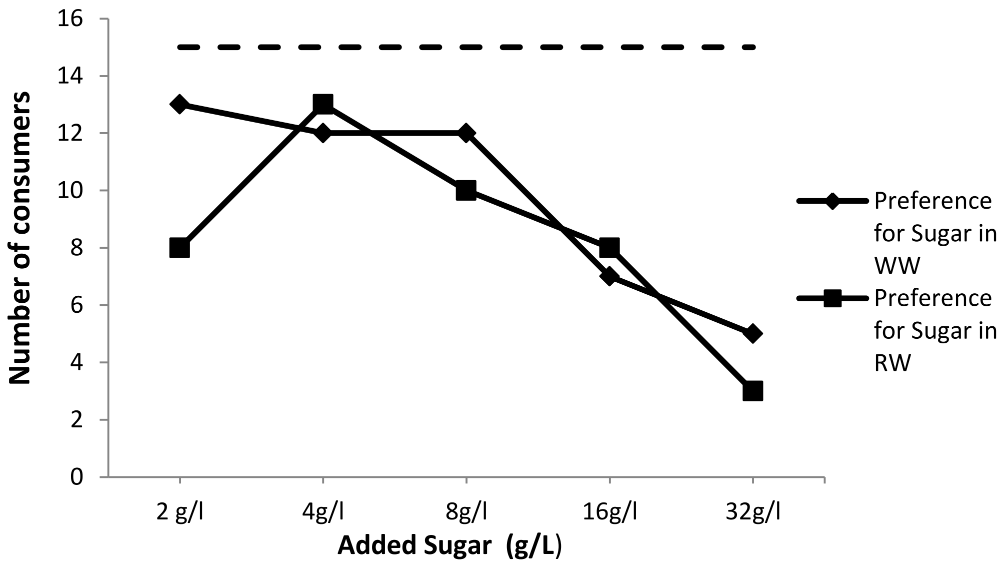

Figure 3.7. Preference for white (WW) and red wine (RW) spiked with sugar in comparison to control.

The inverted-U shape with red wines was similar to that reported but the number of respondents showing preference for sugar did not reach the level for significant difference. Therefore, we changed the responses to preference for the control (Figure 3.8). According to International Standard ISO 5495 with a total of 21 tasters the number for statistical significance is 15. By interpolation we obtained the preference thresholds of 26.4 g/L for the red wine and 32 g/l for the white wine (Figure 3.8).

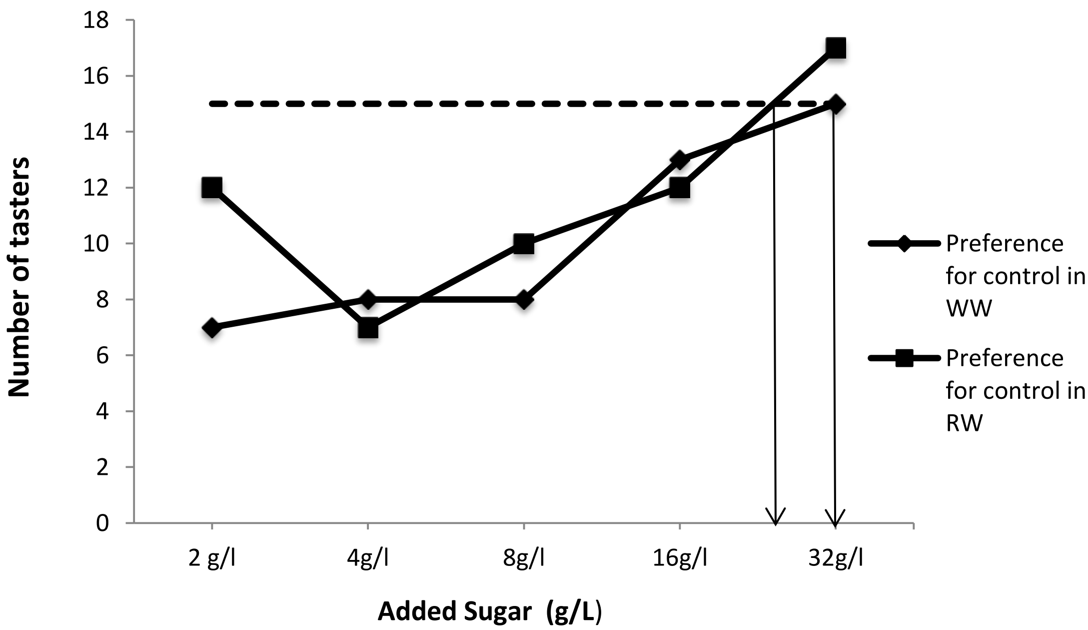

Figure 3.8. Preference for control in white (WW) and red wine (RW) in comparison to wines spiked with glucose plus fructose.

The influence of food on the preference for red wine spiked with sugar is shown on Figure 3.9. We can observe a significant number of tasters in the highest concentration 32 g/L preferring the control, before and after food. The preference threshold was estimated by interpolation to be 18.4 g/L in both cases. Comparing figure 3.8 and 3.9 the behaver of tasters is very similar, this shows that food had no influence in wine preference as they had the same behaver in the tasting without food. In Sena-Esteves (2016) study, the subjects behaved in the same way, having a preference for the middle concentration of red wine spiked with sugar.

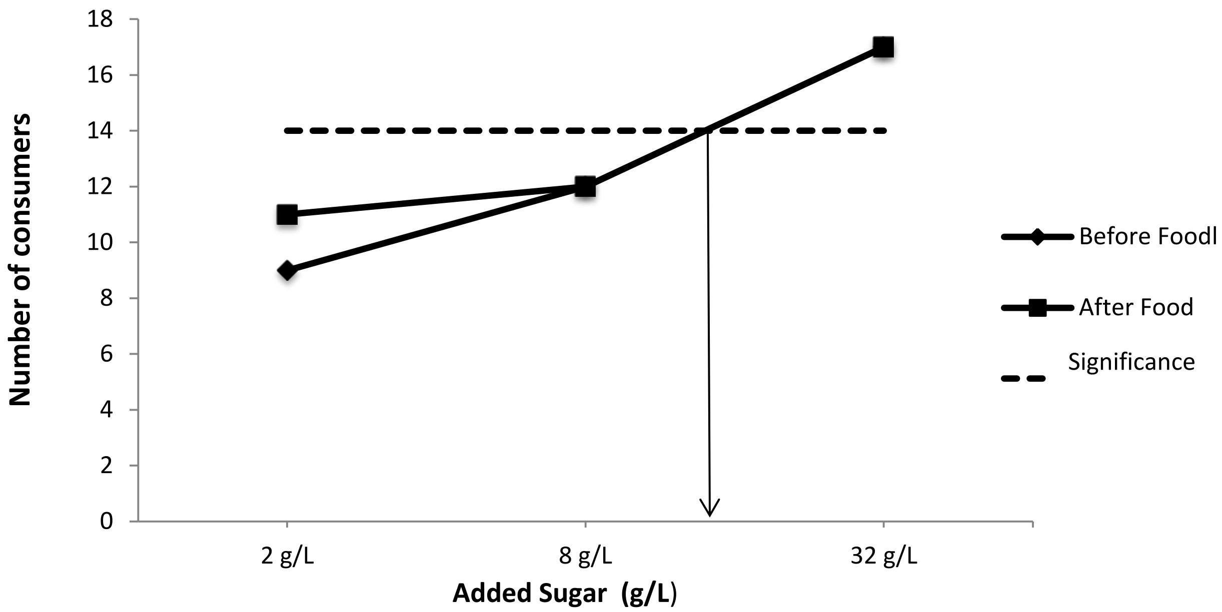

Figure 3.9 Preference for control in red wine with and without food

3.4 Influence of food on the preference for commercial red wines

The wines were evaluated through the establishment of ranking orders. The ranking sum results are shown in table 3.5 for the trained and untrained panels, before and after food consumption. The statistical evaluation of the rankings was performed using several tests as described before. There was a tendency for the trained panel to rank in first place the first wine before the food and the second wine after the food, while the untrained panel before the food ranked the second wine in first place and after the food the third wine was ranked in first place.

Table 3.5 Rank sums for each wine according to tasting panel and food consumption.

	Before Food			After Food		
	W1	W2	W3	W1	W2	W3
Trained panel	40	43	43	46	36	44
Untrained panel	47	36	49	48	45	39

3.4.1 Friedman's test

For the trained panel, Friedman's test (F_{test}) was 2.304 before the food and 4.704 after the food. Both values were below 5.99, concluding there were no differences among the rank order. In the non-trained panel test the F_{test} was 1.77 before food and -0.75 after food, meaning also that there are no differences among the rank order.

In conclusion, using rank orders we could not establish a difference in preference for the 3 wines, irrespective of the tasting experience. Given these results, we tried other statistical tools to check the influence of food consumption on the ranking order.

3.4.2 Evaluation using Pearson's X^2 test

To apply the Pearson's X^2 test to the trained panel we established the possible changes in the ranking of the 3 tasted wines, if changes occur randomly (Table 3.6).

Table 3.6 Number of changes that can occur if the distribution was random (0 no change, 2 changes of place, 4 changes of place)

	123	**132**	**213**	**231**	**312**	**321**
123	0	2	2	4	4	4
132	2	0	4	4	2	4
213	2	4	0	2	4	4
231	4	4	2	0	4	2
312	4	2	4	4	0	2
321	4	4	4	2	2	0

The probabilities corresponding to the null hypothesis are presented in table 3.7 (π_i) of 0, 2 and 4 changes occur if random in a total of 36 possibilities. The observed values (O_i) were the direct results from the tasting with the trained panel and the expected (E_i) values were the probability multiplied by the total of tasters (n=21).

Table 3.7 Probabilities, observed values and expected values for the trained panel.

	0	**2**	**4**
Πi	$\frac{1}{6}$	$\frac{1}{3}$	$\frac{1}{2}$
Oi	6	8	7
Ei (πi·n)	3.5	7	10.5

The calculated statistics

$$X^2calc = \frac{(6-3.5)^2}{3.5} + \frac{(8-7)^2}{7} + \frac{(7-10.5)^2}{10.5} = 3.09$$

This value is lower than $X^2{}_{(3-1)0.05}$, therefore the null hypothesis was not rejected (with α=0.05), meaning that the probabilities were not altered from the ones randomly assumed. In summary, the tasting results have a random order of wine preference with the food. Therefore, we conclude the food had no influence on wine preference.

We performed the same treatment with the untrained panel and the calculated values are listed in table 3.8.

Table 3.8 Probabilities, observed values and expected values for the untrained panel.

	0	**2**	**4**
Πi	$\frac{1}{6}$	$\frac{1}{3}$	$\frac{1}{2}$
Oi	3	6	13
Ei (πi·N)	3.66	7.33	11

$$X^2calc = \frac{(3-3.66)^2}{3.66} + \frac{(6-7.33)^2}{7.33} + \frac{(13-11)^2}{11} = 0.72$$

After the calculations we conclude that $X^2{}_{(3-1)0.05}$ was greater than the $X^2{}_{calc}$ so we did not reject *H0* for α=0.05, the probabilities are not changed significantly. In our case the tasting results did not contradict a random order having no preference and concluding that, as well as the trained panel, food had no influence on wine preference.

3.4.3 Evaluation using the Spearman correlation coefficient

The Spearman correlation coefficient studies the agreement between two rank orders. The values of the Spearman coefficients are shown in figures 3.10 and 3.11 for each of the tasters. With the trained panel only five tasters were below 0 meaning only five revealed clear changes with the food, while the others (16) were above 0 indicating the rank orders were kept with the food (table 3.9). Thus, we can observe a tendency to keep the rank. In the untrained panel (figure 3.11) there were more tasters changing the rank order, with 10 below 0 and 12 above 0 (Table 3.10).

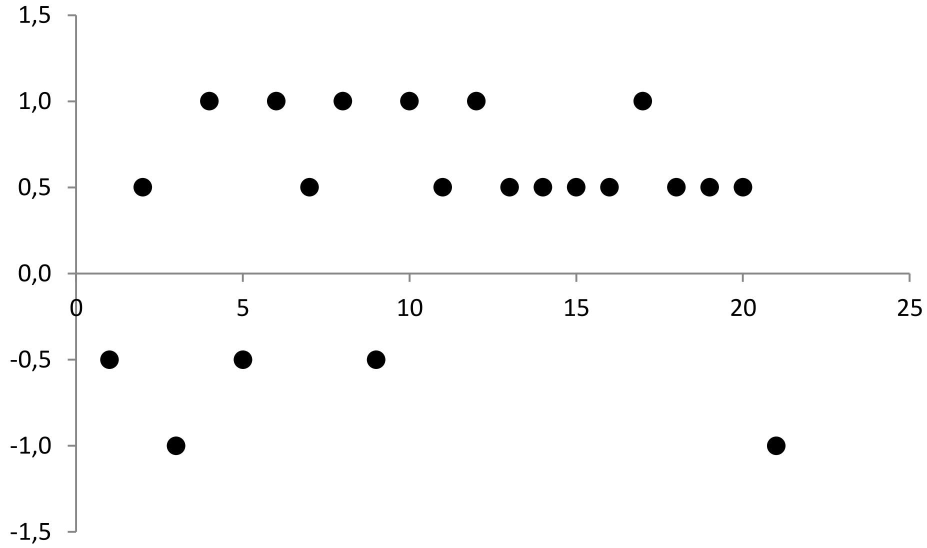

Figure 3.10 Results from the Spearman's test for the trained panel

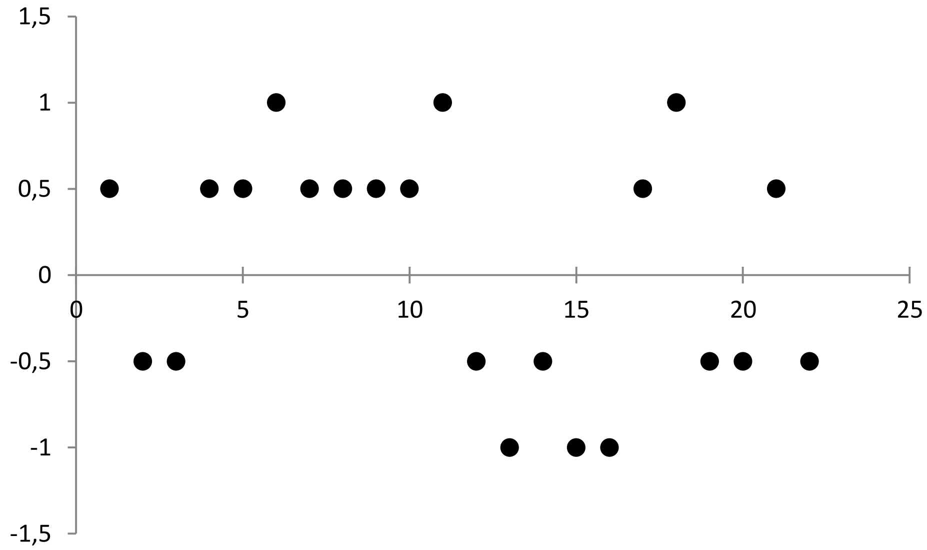

Figure 3.11 Results from the Spearman's test for the untrained panel

Table 3.9 Spearman correlation coefficient of the trained panel

Spearman Correlation Coefficient	Nº of tasters
-1	2
-0.5	3
0.5	10
1	6

Table 3.10 Spearman correlation coefficient of the untrained panel

Spearman Correlation Coefficient	Nº of tasters
-1	3
-0.5	7
0.5	9
1	3

Observing all the tests we can conclude that the food did not influence the appreciation of the tasted red wines. These results are hard to discuss because almost all the studies are made in very different conditions (see table 1.1). Harrington (2008) used in the same tasting, red and white wine while we only have red wines. Koone et al. (2014) used in their work sweet and dry wine and we only had dry wines. Probably the similarity of our dry red wines makes the distinction very difficult for a diverse group of individuals. In addition, the food items used are usually simple. For instance, Harrington (2008) used different cheeses and Lambri et al. (2012) used chocolate, while in this study we prepared "Guisado de Farinheira" which is a relatively complex fatty dish turning all reds adequate to match.

4. Conclusions

According to the objectives in this study we determined the preference threshold for sugar in red wine (26.4 g/L) and in white wine (32 g/L). The intensity and appreciation were measured and we found significant differences according to saliva flow producers and in different vinotypes. In the evaluation of the food effect in sugar preference with red wine the threshold of 18.4 g/L was obtained, but in the evaluation of the food effect in acidity preference we couldn't determine a threshold. Lastly in wine preference with food ingestion we conclude that food did not change the wine preference.

In relation to taste sensitivity, we did not find relation between acid intensity and PROP, saliva flow, vinotype and gender. On the contrary, saliva flow and vinotype were related to acid appreciation, which are results not found by us in literature. In addition, it was very interesting to evaluate how different people felt the bitterness through PROP irrespective of their tasting training, reflecting different genetic taste sensitivities. People do not taste in the same way and after this study this aspect became more evident. It was hard to find straight guidelines to segment tasters and to understand their preferences. Other characterisation of taste phenotype related with sweetness or sourness should be comparatively tested in the future.

We tried several strategies to evidence the effect of food on wine appreciation. However, we could never find statistical difference in responses before and after food. One hypothesis is that the comparison methods were not adequate but we can also speculate that all red wines performed well against food. In spite of their different characteristics, the variability of taster responses had a buffer effect on the overall panel appreciation. Further taster selection considering their individual responses can be useful in future studies and it could also be wise to use a very different wine (e.g. aromatic sweet white wine) as a control.

We cannot follow by letter every rule about wine and food pairing, it is mandatory to understand the relations behind the matching, every individual tastes differently, perceived appreciation and intensity in various levels, so the rules that we are used to listen are not always easy to demonstrate. Further investigations are required to understand the changing of wine appreciation along with food.

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Appendix I – Trained panel test complete information

Table I.1 – Demographic characterisation of the trained panel.

Name	Age	Vegetarian	Food Allergy	Gender	Smoker
Andreia Gomes	22	No	No	Female	No
Ayse Deniz	28	No	No	Female	No
Catarina Chicau	22	No	No	Female	No
Eduardo Muñoz	24	No	No	Male	Yes
Elisabetta Pittari	22	No	No	Female	Sometimes
Federico Bertucci	21	No	No	Male	Yes
Francisco Antunes	23	No	No	Male	Sometimes
Inês Ruivo	23	No	No	Female	No
João Costa	23	No	No	Male	No
João Freire	24	No	No	Male	Yes
João Graça	32	No	No	Male	No
Jorge Mata	22	No	No	Male	No
Lorenza Bazzano	25	No	No	Female	No
Lorenzo Delia	24	No	No	Male	No
Luís Duarte	35	No	No	Male	No
Matteo Federici	24	No	No	Male	Yes
Rafael Veloso	23	No	No	Male	Sometimes
Ricardo Egipto	46	No	No	Male	No
Simone Giannini	24	No	No	Male	No
Sofia Sousa	23	No	No	Female	Yes
Tobias Winkler	26	No	No	Male	Sometimes

Table I.2 Physiological and vinotype characterisation of the trained panel.

Name	Saliva flow (g/min)	Saliva Status	Average PROP (mM)			PROP Status	Vinotype
			0.032	0.32	3.2		
Andreia Gomes	2.85	Low	4.59	10.71	46.41	Non-taster	Sensitive
Ayse Deniz	2.84	Low	71.40	84.66	102.00	Super-taster	Tolerant
Catarina Chicau	2.40	Low	14.79	79.56	93.33	Super-taster	Hipersensitive
Eduardo Muñoz	3.23	Low	1.53	20.91	41.82	Taster	Tolerant
Elisabetta Pittari	3.60	High	20.40	66.81	97.92	Super-taster	Tolerant
Federico Bertucci	4.41	High	16.83	57.12	89.25	Super-taster	Tolerant
Francisco Antunes	2.68	Low	7.14	21.93	58.14	Taster	Sensitive
Inês Ruivo	1.42	Low	4.08	17.34	82.11	Taster	Sensitive
João Costa	4.29	High	14.28	75.48	94.35	Super-taster	Sensitive
João Freire	1.51	Low	1.02	4.08	26.52	Non-taster	Sensitive
João Graça	3.27	Low	5.61	10.71	51.51	Non-taster	Tolerant
Jorge Mata	3.37	Low	9.69	27.03	61.20	Taster	Sensitive
Lorenza Bazzano	3.96	High	11.73	72.93	99.45	Super-taster	Sensitive
Lorenzo Delia	3.55	High	3.57	85.17	102.00	Super-taster	Sensitive
Luís Duarte	2.35	Low	15.81	34.68	82.11	Taster	Sensitive
Matteo Federici	3.84	High	19.38	42.33	74.46	Taster	Hipersensitive
Rafael Veloso	3.45	Low	5.10	45.90	96.39	Taster	Sensitive
Ricardo Egipto	2.12	Low	35.19	87.72	99.45	Super-taster	Hipersensitive
Simone Giannini	2.16	Low	10.71	34.68	61.71	Taster	Sensitive
Sofia Sousa	2.60	Low	6.12	57.12	99.45	Super-taster	Hipersensitive
Tobias Winkler	4.47	High	19.89	59.67	94.35	Super-taster	Sensitive

Appendix II – Non-trained panel test complete information

Table II.1 – Demographic characterisation of the untrained panel.

Name	Age	Vegetarian	Food Allergy	Gender
Cynthia Vieira	38	No	Yes	Female
Diogo Martins	28	No	No	Male
Nídia Figueiredo	22	No	No	Female
Ana Mansidão	22	No	Yes	Female
Diogo Baeta	28	No	No	Male
Emanuel David	33	No	No	Male
Ana Martins	31	No	No	Female
Catarina Leal	20	No	No	Female
Ana Casquinha	24	No	No	Female
Inês Rosa	21	No	No	Female
Paula Pereira	28	No	No	Female
Vasco Martins	32	No	No	Male
José Corrêa	23	No	No	Male
Guilherme Maia	22	No	No	Male
Rodrigo Gonçalves	21	No	No	Male
Leonel Covas	35	No	No	Male
Frederico Ferreira	22	No	No	Male
Pedro Barraco	21	No	No	Male
Eva Silva	22	No	Yes	Female
Ana Marques	24	No	No	Female
Ana Domingos	20	No	No	Female
Rafael Adame	27	No	No	Male

Table II.2 Physiological and vinotype characterisation of the untrained panel.

Name	Saliva flow (g/min)	Saliva Status	Average PROP (mM)			PROP Status	Vinotype
			0.032	0.32	3.3		
Cynthia Vieira	1.215	Low	9.18	87.72	98.94	Super-taster	Sensitive
Diogo Martins	3.230	Low	0	31.62	37.74	Taster	Tolerant
Nídia Figueiredo	1.397	Low	0	0	0	Non-taster	Sensitive
Ana Mansidão	3.660	High	0	15.3	20.4	Non-taster	Sensitive
Diogo Baeta	1.739	Low	8.16	51	65.28	Super-taster	Sensitive
Emanuel David	1.626	Low	16.32	56.1	64.26	Super-taster	Hypersensitive
Ana Martins	1.719	Low	2.04	53.04	74.46	Super-taster	Sensitive
Catarina Leal	1.595	Low	3.06	35.7	66.3	Taster	Hypersensitive
Ana Casquinha	1.378	Low	4.08	7.14	17.34	Non-taster	Sensitive
Inês Rosa	1.382	Low	5.1	43.86	80.58	Taster	Sensitive
Paula Pereira	3.280	Low	5.1	5.1	5.1	Non-taster	Tolerant
Vasco Martins	2.889	Low	12.24	37.74	57.12	Taster	Hypersensitive
José Corrêa	3.044	Low	2.04	92.82	102	Super-taster	Sensitive
Guilherme Maia	2.757	Low	7.14	81.6	100.98	Super-taster	Sensitive
Rodrigo Gonçalves	1.122	Low	0	36.72	45.9	Taster	Sensitive
Leonel Covas	2.186	Low	0	36.72	56.1	Taster	Tolerant
Frederico Ferreira	3.705	High	3.06	83.64	99.96	Super-taster	Sensitive
Pedro Barraco	0.675	Low	7.14	44.88	73.44	Taster	Hypersensitive
Eva Silva	2.942	Low	0	14.28	32.64	Non-taster	Hypersensitive
Ana Marques	0.767	Low	0	13.26	45.9	Non-taster	Sensitive
Ana Domingos	2.137	Low	5.1	7.14	42.84	Non-taster	Hypersensitive
Rafael Adame	2.892	Low	1.02	3.06	5.1	Non-taster	Sensitive

Appendix III – ISA's Wines Analysis

	Free SO_2 (mg/L)	Total SO_2 (mg/L)	pH	Total Acidity (g/L of tar. acid)	Volatile Acidity (g/L of ace. acid)	Alcohol Strength (%v/v)	Reducing Sugars (g/L)
Arinto 2014	26	90	3.41	5.9	0.24	12	1
Cabernet Sauvignon, Touriga Nacional, Syrah and Trincadeira 2014	36	185	3.76	5.7	0.82	14	1.3

Appendix IV – Bola de carne recipe

Ingredients used:

200gr Chouriço - Sabores do Alentejo

150gr Smoked Bacon Strips - Continente

4Eggs - Continente

200gr Oil - Fula

300gr Half Fat Milk - Vigor

300gr Wheat Flour - Branca de Neve

2 Teaspoons Yeast - Royal

1 Teaspoon of Salt - Vatel

1 Tablespoon of Olive Oil - Oliveira da Serra

Method:

In a pan, cook the eggs, milk, oil and salt for 5 minutes. In a food processor put the previous mixture and add the flour and yeast and turn on the processor for 1 minute. Then add the chouriço previously chopped and the bacon. Put the mixture in an oven plate greased with the olive oil.

Appendix V – Stew recipe

Ingredients used:

1 Tablespoon Olive Oil – Oliveira da Serra

1 Garlic Tooth - Continente

440 gr Farinheira – Continente

150 gr Smoked Bacon Strips – Continente

1250 gr Canned Chickpeas – Continente

780 gr Peeled Canned Tomato – Continente

1 Red Bell Pepper - Continente

1 Cube Chicken Stock – Knorr

1 Teaspoon Oregano

Method:

In a pan put the farinheira and the bacon and let release the fat. After 3 to 5 minutes take of the farinheira and bacon to reserve. Add to the pan the olive oil, garlic and bell pepper to let them fry. Add the chickpeas, the tomato and the chicken stock and let boil for 10 minutes. Add the farinheira and bacon to the mixture with the oregano.

Appendix VI – Commercial Wines Analysis

Table VI.1 – Red wine chemical analysis.

Parameter	Aragonez 2013 (Cortes de Cima)	D. Graça Reserva 2011 (Vinilourenço)	Vinha Pan 1999 (Luís Pato)
Color Intensity (ua)	9.290	14.880	10.790
Shade (ua)	0.896	0.816	1.308
Total Phenolics (absorbance units)	57.48	67.20	53.18
Total Anthocyanins (mg/L)	125	85	34
Tannic Power (NTU/mL)	4.5	7.9	5.9
Free SO_2 (mg/L)	12	11	6
Total SO_2 (mg/L)	80	72.5	25
pH	3.51	3.69	3.53
Total Acidity (g/L tartaric acid)	5.7	5.4	5.5
Volatile Acidity (g/L acetic acid)	0.58	0.84	0.66
Alcohol Strength (%v/v)	13.5	14.2	12.9
Dry Extract (g/dm^3)	30.7	35.4	28.1
Reducing Sugars (g/L)	3.2	3.1	2.2

Note: analysis performed at the Ferreira Lapa Laboratory.

Appendix VII – Intensity and Appreciation of tartaric results from tasting

	Intensity				Appreciation			
	0.4 g/L	0.8 g/L	1.6 g/L	3.2 g/L	0.4 g/L	0.8 g/L	1.6 g/L	3.2 g/L
Andreia Gomes	2.5	4.2	5	5.5	3.9	5.2	5.4	7.1
Ayse Deniz	0.7	1.4	7	8.5	3.4	2.4	4.2	1.5
Catarina Chicau	0.9	2.1	5	7.6	7.5	5.7	7	3.7
Elisabetta Pittari	3.9	5.4	7.6	8.6	2	1.7	0.4	1.3
Federico Bertucci	4.2	5.4	6.5	8.4	1.5	1.2	0.7	0.2
Francisco Antunes	3.5	7.4	7.7	8.3	6	1.9	7	2.6
Inês Ruivo	1.3	3	6.2	8.1	1.4	6.6	8.1	3.4
João Costa	1.6	5.1	6.1	8.6	2.2	6.1	4.6	8.2
João Freire	1.1	1.8	5.2	5.7	2.3	3	6.5	4.4
João Graça	0.4	2.7	5.6	8.1	2.1	7.3	5.4	0.5
Jorge Mata	2.1	4.2	5.9	8.9	5.3	8.3	7.3	6.4
Lorenza Bazzano	0.8	1.4	5.6	6.7	1.4	3	2.4	1.7
Lorenzo Delia	1.3	2.2	4.5	5.7	3.1	5.3	6.6	5.9
Luís Duarte	5	7.3	8.4	9.1	8.5	9.4	7.3	6.1
Matteo Federici	1.3	3.1	5	6.5	1.5	8.3	3.5	6.1
Rafael Veloso	0.9	2.6	5	6.5	0.7	5.4	6.9	1.4
Ricardo Egipto	5.4	6	7.9	8.5	6	6.9	3.6	1.1
Simone Gianni	0.8	4	6	7.3	0.5	4	2.6	5.8
Sofia Sousa	0.6	1.7	5.1	9.6	3.9	0.5	5.8	9,4
Tobias Winkler	2.3	3.6	7	7.8	2.9	6.5	6.7	5.1
Mean	2.03	3.73	6.12	7.70	3.31	4.94	5.10	4.10

Appendix VIII – Taste Sheets

Sheet VIII.1 First tasting

Date:__/__/_____	Student Number:_________________
Previous Wine Knowledge:_____________________	Vinotype:________________________

Recognition of simple tastes / sensations. Write after each solution the basic sensation you feel after tasting it.

1- ____

2-____

3-____

4-____

5-____

6-____

What is the difference between the solutions?

A-____

B-____

What is the difference between the solutions?

C-____

D-____

Sheet VIII.2 Second tasting

Date:__/__/_____	Student Number:__________________
Age:_______________	Vinotype:_________________________

Recognition of simple tastes / sensations. Write after each solution the basic sensation / taste you feel after tasting it.

1- __________________________________+____

2-__________________________________+____

3-_________________________+__________________________+______________________

4-___________________+____________________+__________________+______________

In which solution you think has more body?

A-____

B-____

C-____

Sheet VIII.3 Third, fourth and fifth tasting

Date:__/__/_____ Student Number:__________________

Name:____________________________________

There is tree samples of wine in which two are the same and one is different. Try the samples from left to right and cross the one that seems different in each set. Drink somer water between the samples.

1-	☐	☐	☐
2-	☐	☐	☐
3-	☐	☐	☐
4-	☐	☐	☐

If you can please tell why you think the sample you chose its different using the basic sensations that you've been praticing.

1-____

2-____

3-____

4-____

Sheet VIII.4 Sugar preference tasting

Name:____ Age:____________

Vinotype: HS ☐ S☐ TO☐ SW☐

For how long have you been drinking wine?

1 to 3 years ☐ 3 to 5 years ☐ More than 5 years ☐

How many times do you drink wine per week? 1 to 3 ☐ more than 3 ☐

I consider my self: Expert ☐ Interested ☐ Drink for enjoyment ☐

Assess the wine and identify in each pair the glass code the you prefer:

Pair 1:__________________

Pair 2:__________________

Pair 3:__________________

Pair 4:__________________

Pair 5:__________________

Considering the glasses that you chose, did you chose for being more or less soft? Cross with X.

Glass 1: + Soft ☐ -Soft☐

Glass 2: + Soft ☐ -Soft☐

Glass 3: + Soft ☐ -Soft☐

Glass 4: + Soft ☐ -Soft☐

Glass 5: + Soft ☐ -Soft☐

Assess the wine and identify in each pair the glass code the you prefer:

Pair 1:__________________

Pair 2:__________________

Pair 3:__________________

Pair 4:__________________

Pair 5:__________________

Considering the glasses that you chose, did you chose for being more or less soft? Cross with X.

Glass 1: + Soft ☐ -Soft☐

Glass 2: + Soft ☐ -Soft☐

Glass 3: + Soft ☐ -Soft☐

Glass 4: + Soft ☐ -Soft☐

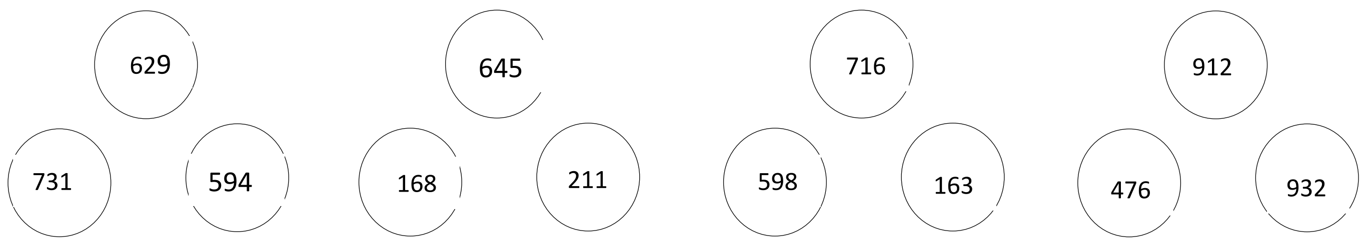
Glass 5: + Soft ☐ -Soft☐

Sheet VIII.5 Intensity and appreciation of tartaric acid

Name:________________________________ Date:_________________

1.1) Taste each set and, inside each one, tell which is the different glass and why. If you are not able to identify the different one, don't leave it white but choose one anyway. After you have finished with one set and move to the next, you cannot come back to the previous ones.

1 **2** **3** **4**



1.2)

	N° of the different one	Reason why is different
1		
2		
3		
4		

BEFORE TO GO ON WITH THE NEXT STEPS, PLEASE CALL US AND WE'LL CHECK THE PREVIOUS RESULTS

2.1) With the samples we showed you, write them in the scale, according with the intensity that you percived. The order of the numbers as to be manteined.

2.2) With the same samples we showed you, write them in the scale, according with the appreciation that you percived. The order of the numbers can be inverted.

Sheet VIII.6 Sugar preference in red wine with food tasting and Acid preference in white wine with food

Name: ________________________________ **Date:** ____/____/________

Assess the wine and identify in each pair the glass code the you prefer:

Pair 1:_______________________

Pair 2:_______________________

Pair 3:_______________________

Considering the glasses that you chose, why did you choose?

-Sweet ☐ -Rough ☐ +Sweet ☐ +Rough ☐

-Sweet ☐ -Rough ☐ +Sweet ☐ +Rough ☐

-Sweet ☐ -Rough ☐ +Sweet ☐ +Rough ☐

Name: ____________________________ **Date:** ____/____/________

1. Taste the food, assess the wine and identify the glass code that you prefer with the food. Repeat the same process with the other pairs. Considering the glasses that you chose, did you chose for being more or less soft?

Pair 1:_______________________ -Sweet ☐ -Rough ☐ +Sweet ☐ +Rough ☐

Pair 2:_______________________ -Sweet ☐ -Rough ☐ +Sweet ☐ +Rough ☐

Pair 3:_______________________ -Sweet ☐ -Rough ☐ +Sweet ☐ +Rough ☐

Sheet VIII.7 Prop and saliva tasting

Name: ____ Student Nº____________

Vinotype: ______________________ Food Allergy: _______________ Vegetarian:_________

Course: _________________________ Age: _________ Gender: ___________

Taste the sample given to you, hold it in mouth for 10/15 seconds. Spit it out. Hold for another 10 seconds and spit in the plastic cup for a minute.

Initial Weight__________ Total Weight____________ Saliva Weight______________
(Number in the cup)

Taste the samples from left to right. According to your sensibility write on the scale the marks 1, 2 and 3 where you feel the intensity. The left side corresponds to non-feeling and the right side is the highest sensation you could imagine.

Sheet VIII.8 Appreciation of commercial red wines with food tasting

Name: ______________________ Date: ___/____/___ Vinotype: ___________

Taste and assess the wines. Write the code of the glass in order (1st : the best to 3rd the worst) :

1st place:______________

2nd place:______________

3rd place:_______________

Taste the food and then taste the wine. Repeat the same process for the other wines. Write the glass code that you prefer with the food in order (1st : the best to 3rd the worst). Considering the glasses that you chose, did you chose for being more or less soft?

1st place:______________

2nd place:______________

3rd place:_______________

Appendix IX – Commercial red wines tasting results of trained panel

	Before Food			After Food			SCC*
Name	W1	W2	W3	W1	W2	W3	
Andreia Gomes	2	3	1	3	1	2	-0,5
Catarina Chicau	2	1	3	1	2	3	0,5
Deniz Ayse	1	3	2	3	1	2	-1,0
Eduardo Munoz	3	1	2	3	1	2	1,0
Elisabetta Pittari	1	2	3	3	1	2	-0,5
Federicci Bertucci	2	1	3	2	1	3	1,0
Francisco Antunes	2	1	3	3	1	2	0,5
Guilherme Vitorino	3	2	1	3	2	1	1,0
Inês Ruivo	1	2	3	2	3	1	-0,5
João Costa	3	1	2	3	1	2	1,0
João Freire	3	2	1	3	1	2	0,5
João Graça	3	2	1	3	2	1	1,0
Lorenza Bazzano	1	2	3	1	3	2	0,5
Lorenzo Delia	1	2	3	2	1	3	0,5
Luís Duarte	2	3	1	1	3	2	0,5
Rafael Veloso	2	3	1	1	3	2	0,5
Ricardo di Guilio	1	3	2	1	3	2	1,0
Ricardo Egipto	2	3	1	3	2	1	0,5
Simone Giannini	1	2	3	2	1	3	0,5
Sofia Sousa	2	1	3	1	2	3	0,5
Tobias Winkler	2	3	1	2	1	3	-1,0
Total	40	43	43	46	36	44	

*SCC – Spearman Correlation Coefficient

Appendix X – Commercial red wines tasting results of untrained panel

	Before food			After food			SCC*
Name	W1	W2	W3	W1	W2	W3	
Cynthia Vieira	2	1	3	1	2	3	0,5
Diogo Martins	3	1	2	2	3	1	-0,5
Nídia Figueiredo	2	1	3	1	3	2	-0,5
Ana Mansidão	3	1	2	2	1	3	0,5
Diogo Baeta	1	3	2	2	3	1	0,5
Emanuel David	3	2	1	3	2	1	1,0
Ana Martins	3	1	2	3	2	1	0,5
Catarina Leal	3	1	2	3	2	1	0,5
Ana Casquinha	3	2	1	3	1	2	0,5
José Corrêa	2	3	1	1	3	2	0,5
Guilherme Maia	1	2	3	1	2	3	1,0
Rodrigo Gonçalves	3	2	1	2	1	3	-0,5
Frederico Ferreira	1	2	3	3	2	1	-1,0
Pedro Barraco	3	1	2	1	2	3	-0,5
Eva Silva	1	2	3	3	2	1	-1,0
Ana Marques	2	1	3	2	3	1	-1,0
Rafael Andame	1	2	3	2	1	3	0,5
Corina Blidori	3	2	1	3	2	1	1,0
Luís Mendes	1	3	2	3	2	1	-0,5
José Queiroz	2	1	3	3	2	1	-0,5
Sara Fonseca	2	1	3	3	1	2	0,5
Paula Martins	2	1	3	1	3	2	-0,5
Total	47	36	49	48	45	39	

*SCC – Spearman Correlation Coefficient